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ARTICLE

Development and Implementation of Checklist Management in Manned Space Medical Rescue Transfer and Handover

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Abstract: Background Medical rescue transfer and handover in manned spaceflight is a critical component of space rescue operations, directly impacting the safety and well-being of astronauts. Objective This study aims to develop a comprehensive checklist for the medical rescue transfer and handover processes associated with manned spaceflight, thereby enhancing the efficiency of these procedures. Methods The checklist was designed and implemented during practical training sessions focused on manned space medical rescue. Participants were divided into two groups: one utilizing the checklist for transfer handover and another relying on verbal communication. Key metrics such as transfer time, quality of handover, and satisfaction scores were collected and analyzed for both groups. Results The group employing the checklist demonstrated significantly improved outcomes compared to the verbal group in terms of transfer time, quality of handover, and overall satisfaction scores ($P < 0.001$). Conclusion The implementation of checklist management has been shown to enhance both the efficiency and quality of transportation and handover processes, establishing a robust foundation for successfully executing manned space medical rescue missions.

Keywords: Manned Space Medical Rescue; Transfer; Handover; Checklist Management

INTRODUCTION

China's manned space program has advanced to the stage of conducting missions involving a space station, resulting in significantly extended durations for astronauts' stays. These missions are increasingly arduous and complex, which elevates the likelihood of accidental injuries and illnesses [1,2,3]. Space medical rescue is a critical component in ensuring astronaut safety and constitutes an essential aspect of manned space system engineering [4,5]. The efficiency and quality of transfer and handover during medical rescue directly impact the stability and prognosis of astronauts. Research indicates that standardized transfer handovers can reduce handover time, enhance accuracy and efficiency, and decrease the occurrence of adverse events. Checklist management has emerged as an effective strategy to mitigate errors arising from oversight; it offers advantages such as rapid comprehension, straightforward implementation, and precise handovers [6,7]. Currently, checklist management has been successfully employed in emergency evacuation and transfer protocols by foreign Marine Corps units, yielding positive outcomes in reducing adverse incidents while improving the quality of transfers and handovers [8].

This study aims to implement checklist management within nursing transfer processes during aerospace medical rescue training. A statistical analysis will be conducted on the time taken for these transfers, the quality achieved therein, as well as satisfaction levels among nursing staff compared with traditional oral handovers. This approach seeks to provide insights into methodologies for enhancing both the quality and efficiency of aerospace medical rescue operations alongside nursing transfers and handovers.

One population that has been identified as vulnerable to acquiring HIV infection is military personnel, due to frequently reported high-risk sexual behaviour [9,10] or to their high mobility and exposure to biologically foreign environments [11,12].

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MATERIALS AND METHODS

1. Design of transfer handover list

By convening a panel of eight experienced experts in the field of space medicine, we developed a comprehensive checklist for manned space rescue, transfer, and handover procedures. In designing the content, we prioritized the timeliness of first aid interventions prior to astronauts exiting their cabin. This checklist encompasses critical information including the arrival time of medical rescue personnel, the timing of astronaut cabin egress, on-site emergency treatment duration, astronaut evacuation timing, as well as vital signs monitoring and condition changes throughout the evacuation process [8]. As illustrated in Table 1, the handover list is categorized into four dimensions comprising fifteen items:

(1) Basic Information: This section includes data such as astronaut identification number, gender, age, exit time from the cabin, and entry time into the medical transport vehicle.

(2) Preparation Before Transport: This dimension covers essential vital signs of astronauts prior to transport along with safety measures for astronauts themselves; it also addresses preparations by medical staff and necessary equipment.

(3) Observation During Transport: Key observations during transportation include monitoring astronauts' vital signs—such as consciousness level, blood pressure readings, heart rate fluctuations, oxygen saturation levels—and noting any sudden changes in their condition.

(4) Transfer and Handover: The final category consists of data regarding consciousness levels and vital signs at transfer points; skin status assessments; past medical history including allergies; venous access details; artificial airway management; and medications administered during transit.

The signature section was duly signed off by both nursing staff involved in pre-cabin treatment and transport as well as receiving nursing personnel at the destination hospital. Additionally, precise records were maintained detailing each step of an astronaut's transfer to a ward down to minute-level accuracy. The transfer handover documentation exists in duplicate copies that are stored separately to serve as formal handover references.

Table 1: Astronaut transfer handover record sheet

Astronaut transfer handover record sheet				
Basic Information	Number: Gender: Age: Astronaut out time: Into the medical carrier time:			
Preparation	Personnel Preparation: Doctor ☐ Nurse ☐ Departure time:			
	Vital Signs: T: ℃; P: times/min; R: times/min; BP: mmHg; SPO_2: %			
	Safety Protection: Head and Neck Fixator ☐ Limb Protection ☐ Transport Equipment Good Performance Mouth ☐			
	Equipment: ECG Monitoring ☐ Oxygen Bottle ☐ Defibrillator ☐ Sputum Suction Equipment ☐ First-aid Case ☐			
In transit (Observation)	Vital Signs: T: ℃; P: times/min; R: times/min; BP: mmHg; SPO_2: %			
	State of consciousness: Awake ☐ Somnolence ☐ Lethargy ☐ Light Coma ☐ Deep Coma ☐ Delirium ☐ Agitation ☐			
	Pupil Condition: Left ( ) Right ( ) Light reflex: Sensitive ☐ Slow ☐ Absent ☐			
	Changes in Condition	No ☐ Yes ☐		
Transfer & Handover	Vital Signs: T: ℃; P: times/min; R: times/min; BP: mmHg; SPO_2: %			
	Past history	No ☐ Yes ☐	History of Allergies	No ☐ Yes ☐
	Pipe line	Artificial Airway	No☐ Oxygen Tube ☐ Mask ☐ Oropharyngeal Airway ☐	

			Tracheotomy ☐ Tracheal intubation ☐ Depth of intubation: Ventilator parameters:
		Venous Channel	No ☐ Yes ☐ Indwelling Needle ☐ Bone Marrow Puncture ☐ Site: Puncture Time:
		General	No ☐ Abdominal Cavity Drainage Tube ☐ Thoracic Cavity Drainage Tube ☐ Others:
			Catheterization Time: Leakage Length: Pipe Clamp End: Yes ☐ No ☐
	Medication	Special Drugs	Yes ☐ No ☐ Name/Dose :
		General Drugs	Yes ☐ No ☐ Name/Dose :
	Skin	No ☐ Yes ☐ Site:	

Signature of Pre-cabin Emergency Nurse: Signature of Post-cabin Hospital Nurse: Handover Completion Time:

2. Training of transfer handover list

After the completion of the design for the transfer and handover checklist, nursing staff training was conducted by the organizers in accordance with expert consensus on astronaut treatment before the re-entry module of the landing site of space station mission[4]. This training also adhered to the Standard Operating Procedure (SOP) for emergency medical care for astronauts[9,10,11], as well as operational specifications pertaining to medical care and support during space station missions[12,13]. Methods such as group discussions and scenario simulation demonstrations were employed to elucidate each item on the checklist systematically. The effectiveness of this training was assessed through on-site questioning, ensuring that participants comprehensively understood each item and minimizing potential errors in documentation.

3. Group study on the transfer handover list

To implement the transfer and handover checklist in manned space medical rescue training, a study was conducted with two groups: a control group utilizing traditional oral handover methods and an experimental group employing the checklist handover approach. Each group consisted of 15 participants. The metrics evaluated included transfer preparation time, transfer handover time, and total transfer time.

Transfer preparation time refers to the duration required for the simulated astronaut to enter the transport carrier, during which the medical team counts personnel, consumables, and equipment while confirming both the condition of the injured individual and the status of all equipment. Transfer and handover time encompasses the period needed for the simulated astronaut to exit from the transport carrier and be transported to the astronaut ward. This phase includes transferring essential information such as basic details, vital signs, level of consciousness, and any changes in condition between pre-cabin rescue nursing staff and posterior support hospital nursing staff.Total transit time is defined as the cumulative sum of both transit preparation time and transit handover time.

4.Evaluation

The handover process with the posterior branch hospital was systematically evaluated by the training team leader during each transfer. The quality of handover for both the experimental group and the control group was assessed based on three key components: preparation prior to transfer, the actual transfer and handover process, and comprehension of the patient's disease status. Each component was assigned a score ranging from 1 to 3 points, where 3 points indicated excellent performance, 2 points denoted good performance, and 1 point represented fair performance.

Concurrently, a satisfaction questionnaire was distributed to nursing staff at the backward branch hospital to gauge their satisfaction regarding the transfer and handover process across six dimensions: vital signs monitoring, level of consciousness, changes in condition,

venous access management along with other pipelines, medication administration, and skin conditions. Each aspect received a score between 1 (minimum) and 10 (maximum).

5.Statistical analysis

All data were analyzed using IBM SPSS Statistics 24 . Measurement data that conformed to a normal distribution were presented as mean(M) ± standard(SD) deviation. Count data were expressed in terms of frequency (percentage). The comparison of normally distributed measurement data between the two groups was conducted using an independent samples t-test.

RESULTS

1. Transit time

The transfer time was significantly reduced in the experimental group compared to the control group. In the experimental group, the transfer preparation time averaged 13.27±1.10 minutes, while the transfer handover time was 9.73±1.67 minutes, resulting in a total transfer time of 23.00±1.89 minutes. Conversely, in the control group, the average transfer preparation time was 18.13±2.07 minutes and the transfer handover time was 14.80±1.97 minutes, leading to a total transport time of 32.93±2.84 minutes. The difference between these two groups was statistically significant (P <0.001). Detailed results are presented in Table 2.

Table 2: Comparison of transit times in different groups

Groups	Number	Transit Preparation Time (min)	Transfer Handover Time (min)	Total Transit Time (min)
Control group	15	18.13±2.07	14.80±1.97	32.93±2.84
Experimental group	15	13.27±1.10	9.73±1.67	23.00±1.89
T		10.21	13.65	15.1
P		<0.001	<0.001	<0.001

2. Quality of transfer handover

The scores of the experimental group surpassed those of the control group across three dimensions: preparation prior to transfer, the transfer and handover process, and mastery of disease status. As illustrated in Table 3, the mean scores for preparation before transfer, transfer handover process, and mastery of disease status in the experimental group were 3.00±0.00, 2.53±0.51, and 2.60±0.50, respectively. In contrast, the corresponding scores for the control group were 2.40±0.13, 1.67±0.49, and 1.60±0.63. The differences between these two groups were statistically significant (P < 0.001).

Table 3: The quality of transfer handover was compared in different groups

Groups	Number	Prepare Before Transfer	Transfer Handover Process	Mastery of Disease Status
Control group	15	2.40±0.13	1.67±0.49	1.60±0.63
Experimental group	15	3.00±0.00	2.53±0.51	2.60±0.50
T		-4.58	-6.5	-5.12
P		<0.001	<0.001	<0.001

3.Satisfaction

Table 4 presents the satisfaction survey scores of medical staff at the posterior branch hospital. The satisfaction scores for the experimental group regarding vital signs, state of consciousness, condition changes, venous access and various pipelines, medication, and skin conditions are as follows: 9.83 ± 0.27, 9.41 ± 0.37, 9.56 ± 0.38, 9.41 ± 0.37, 9.66 ± 0.38, and 9.67 ± 0.38 respectively. In contrast, the control group's satisfaction scores in these same categories were: vital signs (8.73 ± 0.45), state of consciousness (8.57 ± 0.39), disease changes (8.75), venous access and each pipeline (8.63 ± 0.46), medication (8.79 ± 0 .41), and skin conditions (8 .59± 0 .50). The results indicate that the experimental group exhibited significantly higher satisfaction levels compared to the control group (P < 0 .001).

Table4: Comparison of disability among soldiers with different reasons

Groups	Number	Vital Signs	State of Consciousness	Changes in Condition	Pipe Line	Medication	Skin
Control group	15	8.73±0.45	8.57±0.39	8.75±0.41	8.63±0.46	8.79±0.29	8.59±0.50
Experimental group	15	9.83±0.27	9.41±0.37	9.56±0.38	9.41±0.37	9.66±0.38	9.67±0.38
T		-9.39	-8.82	-8.84	-6.24	-8.56	-7.63
P		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

DISCUSSION

To ensure the life and health of astronauts is fundamental to manned space projects. A review of the history of manned space flight worldwide reveals a number of accidents that have resulted in significant losses. In the United States, there have been 19 incidents and failures during manned space flights, leading to 18 fatalities. The former Soviet Union conducted numerous manned space missions, which also resulted in injuries among astronauts, including six deaths [14,15]. To date, all of China's manned space missions have been successfully completed without any serious injuries. As our country embarks on a new phase with its space station program, the frequency of manned launch missions is increasing, while records for in-orbit flight durations continue to be extended. This rise introduces unforeseen factors and maintains an ongoing risk of accidental injury to astronauts. In the event of such an accident, medical rescue serves as the final safeguard for astronaut safety.

The transfer and handover process is a critical component of aerospace medical rescue, significantly influencing the prognosis of injured individuals and patients. The occurrence of adverse events during transfer and handover is closely associated with various factors, including equipment issues, patient conditions, communication barriers, and other challenges faced by medical personnel [16,17]. Implementing an appropriate transfer and handover checklist can enhance communication efficiency among medical staff, enabling them to quickly and effectively comprehend the patient's condition while minimizing the risk of overlooking essential information. This ultimately ensures the safety of patients during their transfer [18,19].

By utilizing a standardized checklist for transfer handovers that delineates key points and critical content in written form, a unified standard is established. This approach improves both the accuracy and efficiency of the transfer process while preventing omissions of vital items. Consequently, it facilitates evidence-based practices in transfer handovers and safeguards patient safety throughout this procedure [20]. Research indicates that employing a checklist for handovers can reduce the incidence of adverse events during transfers from 13.8% to 5.4%, thereby significantly enhancing both quality and efficiency in these processes [21].

Checklist management was implemented in the transfer and handover process of aerospace medical rescue training. Utilizing a transfer and handover checklist, each item was marked off systematically, resulting in a rapid and concise documentation process with accurate and clear recorded content. The critical links that are often overlooked during handovers were consolidated into a standardized format to mitigate the risks associated with oral communication, thereby reducing the likelihood of omissions or repetitions. This approach not only saves time during transfers but also ensures that medical personnel at receiving hospitals have comprehensive access to vital signs and overall injury assessments of simulated casualties throughout the entire evacuation process [22]. The findings from this study indicated that the checklist-based handover group (experimental group) outperformed the oral handover group (control group) significantly across two evaluation metrics: transfer handover time and quality. Furthermore, medical staff at the receiving hospital expressed markedly higher satisfaction regarding six key aspects of the transfer process compared to their counterparts in the oral handover group (control group).

The practice of aerospace medical rescue training has demonstrated that checklist management offers several advantages:

(1) Ensuring the accuracy of transfer and handover information. Traditional oral handovers often suffer from inaccuracies in information transmission, ambiguity regarding key content, omissions of critical disease data, and sometimes deficiencies in the objectivity, accuracy, and completeness of the conveyed information. These unclear handovers and existing shortcomings directly impact the quality of care following transfer. By utilizing a tabular format, a nursing transfer and handover checklist can effectively reflect the basic situation and condition of simulated astronauts in a simple, comprehensive, and intuitive manner. This checklist provides complete information—including vital signs, illness details, rescue efforts, and nursing considerations—for medical personnel at posterior support hospitals. It serves as both a reference point for handover tasks and contributes to making the process more standardized and evidence-based.

(2) Improving the quality and efficiency of transfers and handovers. The checklist facilitates an item-by-item review according to its contents during handover sessions; this approach significantly reduces omissions related to key content or data due to limitations in energy levels or memory capacity among medical staff—factors exacerbated by misunderstandings or time constraints. Consequently, it shortens overall handover duration while substantially enhancing its quality. Research findings indicate that groups utilizing checklists for handovers performed significantly better than those relying on oral communication concerning both transfer times and overall quality of transfers. Following implementation of checklist-based procedures for handing over responsibilities, there is clear evidence that both efficiency and quality are markedly improved while ensuring safety and timeliness throughout the process.

(3) To ensure the safety of astronaut transportation, space medical rescue is critical to both the life and safety of astronauts as well as the overall success or failure of the mission. In the event that an astronaut sustains an accidental injury, there are heightened risks associated with the transfer process. The implementation of a checklist handover serves as a safe nursing practice designed to facilitate effective communication before, during, and after the transfer based on a predetermined transfer handover list [23]. The self-designed transfer handover checklist plays a vital role in conducting risk assessments prior to transfer, thoroughly evaluating timing considerations, and emphasizing careful monitoring of conditions along with emergency interventions throughout the transfer process. Upon safely reaching their destination for transfer, this checklist is utilized once more to convey essential information

regarding vital signs, consciousness levels, venous access status, various drainage tubes in place, medication administered, and any changes in condition experienced by the astronauts. This systematic approach proves beneficial for medical personnel at receiving facilities by enabling them to swiftly assess conditions and execute necessary procedures effectively.

CONCLUSION

With the successful completion of the inaugural in-orbit rotation involving the astronaut teams of Shenzhou 14 and Shenzhou 15, China's space station has transitioned into a long-term operational mode. Consequently, space medical rescue and support missions will now be conducted under standard working conditions. This study demonstrates that effective checklist management can enhance both the efficiency and quality of the transfer handover process. The objective of this approach is to normalize, standardize, and systematize the procedures for space medical rescue transfers and handovers, thereby establishing a robust foundation for the successful execution of astronaut medical support and rescue operations.

Conflicts of interest and sources of funding

The authors declare no conflict of interest and this research received no external funding.

Authors' contribution

The initial draft was prepared and revised by JL, while GH, PS, XG, and LD contributed to the collection of information and the preparation of the dataset. YW further refined the analyses and provided essential support for the manuscript. LS and YT supervised all aspects of the study, including the design of the data analysis plan, oversight of the data analysis process, validation of results, and writing of the manuscript based on the first draft. All authors participated in reviewing and finalizing the manuscript; furthermore, all interested parties have read and approved it.

Ethics approval and consent to participate

This study does not consider pertinent ethical issues related to individuals.

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